Evaluating the effectiveness of using touch sensor capacitors as an input device for a wrist watch computer

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Abstract

On the go computing is becoming more important for users who wish to access information from anywhere. Wearable computers are an optimal solution to achieving this feat because it allows for easy accessibility and quick use. There are many challenges that arise with small computers worn on the body. One of the most common issues is the interaction between the computer and the user and more specifically how the user enters input. In this paper we research a potential effective way to interact with a wrist watch by mounting touch sensors on the watch band.

1. Introduction

Over the past few years, computing technology has continued to increase in speed while decreasing in size. Gone are the days of vacuum tube computers that would take up an entire room; they have been replaced with computers that give access to the user all of the time. The newest technology that has arisen today is the invention of the wearable computer. These types of computers are seen in the form of PDAs or of small PCs which use a head mount display and single handed keyboard and mouse.

Wearable computers are being deployed in a variety of fields ranging from military use to helping people with visual impairments. Wearable computers enable people to have access to computing in places where they were previously unable to take advantage of computing. For the business user, the computer could remind the user of appointments, automatically schedule meetings, as well as open relevant notes and documents while the user talks about a particular subject. For the student user, it allows for the ability to take notes in class without having to look away from the board and be reminded of homework assignments and upcoming test.

One advantage to having a computer that is worn on the body is that it provides constant interaction between the user and the computer; there is no need to constantly power off the device. Another advantage is the ability to multi task. The user is able to interact with other objects in his environment and use his vision or hearing which normally becomes impaired when using a desktop or even a laptop computer.

In addition to portable hardware, wearable computers have also been defined in terms of augmented reality to describe “the user interface technique that allows focusing the user’s attention, observable and controllable by the user, attentive to the environment, useful as a communication tool, and personal tool. [9]

Within the next couple of years wearable computers could become a replacement to today’s laptops. Some wearable computers now consist of the hardware of the computer being worn on the hip or in a case and the display attached to glasses and using a Twiddler USB keyboard and mouse combination to allow for one handed input to the computer. Mobile phones are also becoming another option for wearable computers as they become faster and take on more tasks. Having a computer on your wrist is also an effective way for wearable computing. The watch that was worn in the movie Dick Tracy could not be far from reality. The watch would be in the form of a 3G cell phone wristwatch with an integral antenna, microphone, speaker, color display, and color camera for two way video. [10]

The wrist watch is popular because it is instantly accessible and does not have to be removed from a pocket or a hip holster in order to be used by the user. People have been wearing watches since the 19th century. Watches are always visible and easy to access from the wrist. Digital watches have been developed to include functions such as a stop-watch and alarms. Other watches have been developed to include compasses, phone books, and GPS.

As the size and shape of the computer get smaller, the challenge arises of how to efficiently provide the user with the ability to input information and view a display screen.

We will develop a prototype of a wrist band that uses touch sensor capacitors to capture input to a wrist watch. To evaluate the wrist band's effectiveness we will attach the band to an emulator that imitates a wrist watch computer in terms of display size and run two sample applications that could make use of the touch sensor interface.

2. Wrist Watch Input Devices

Many input systems have been implemented into a wrist watch interface. In the next section, we will discuss examples of wrist watch computers and what type of input interface they used and how effective the system is.

Seiko created an OnHand PC in 1999 which had a monochromatic display of 102x64 pixels. [7] The watch contains 30 applications including different clock faces, PIM features, and games. The OnHand PC uses an operating system called W-PC-DOS which is custom built. It also syncs to a desktop computer using a serial cradle and software. The device also supports wireless connections. For an input system, the watch uses several small buttons on each side of the watch display and a small joystick below the display to serve as a directional pad. While the joystick was an effective device the buttons on the side of the display would be hard to press if you have large fingers because the buttons were placed too close together.

IBM Research Divisions created wristwatch models between 1999 and 2002. [2] These models include the WatchPad 1.0 – 1.5 which uses an ARM 7 processor and runs a Linux Kernel. Each watch has a touch screen and a roller wheel for user input. The major differences in the watches are the display specifications. Version 1.0 uses a 96x120 LCD, 1.1 uses a 640x480 OLED, and 1.5 uses 320x240 4 bit LCD. The developers at IBM were able to accomplish many tasks with the different versions of the WatchPad but production on it stopped in 2002. IBM Research Divisions did not put any buttons on the first two versions of the WatchPad. [2] They discovered that people found buttons on wristwatches hard to use; it was hard for users to remember what each button did if there were more than two buttons on a watch. They also found it was hard for users to push the correct buttons particularly if there were many small buttons that were close to one another. Version 1.5 included three buttons to provide a fast path for some applications. Alphanumeric user interfaces using typed commands are inappropriate, since there is not enough space on the device to implement a keyboard and other character entry methods are quite time consuming and tedious for extended use.

Researchers at the University of South Australia and Hewlett Packard Labs have also created a prototype that involves having a watch interface with no input device. [8] They used Bluetooth to communicate to a server that performs the processing for the watch. This would allow for the watch to interact with household devices. The server is responsible for all complex program logic, and the watch device only receives, decodes, and displays raw image data. This development allows for less energy to be consumed by the watch because it is not responsible for the processing power. A drawback of the University of South Australia prototype implementation is that the user would only be able to use the watch when he was near the server making it impossible to use the watch “on-the-go”.

Researchers at Columbia University created an input system that is based on bidirectional strokes that are segmented by tactile landmarks. [1] This implementation does not require the navigation of an on-screen cursor nor the use of on-screen widgets. Tactile landmarks involve breaking the watch display into quadrants to simulate buttons. This allows for easy menu selection as the corners of the frame can be easily felt by the finger. Bidirectional strokes involve the user being able to determine, through their sense of touch, the length of a given stroke as measured in landmark-to-landmark length, without looking at the device. The tactile landmarks serve as starting, stopping, and intermediate points, as the fingertip of the user moves in a circular gesture on the edge, along the frame of a touchscreen, or on the bezel of a watch. [1] The researchers do not address text entry as this implementation is most effective as a menu navigation system.

2.1 Text Entry

A key challenge to making wrist watch computers user friendly is the ability to enter in text sufficiently. Many different approaches have been taken to solving this problem.

Researchers at Washington University developed the TiltType as a way to enter text on a small mobile device. To enter a character, the user tilts the device and presses one or more buttons. The character chosen depends on the button pressed, the direction of tilt, and the angle of tilt. [5] While this method could prove effective, it would cause the user's forearm to tire quickly which would result in the watch being used less.

Using touch sensor capacitor would allow for data to be entered the same way a user would enter it on a mobile phone. The user would have the option of using multi-tap or predictive text entry.

There hasn't yet been a complete system that solves the issue of both menu selection and text entry. IBM's Watchpad attempts to use small buttons close together [2], while the Onhand PC used buttons and a joystick [7]. We feel that using touch sensor capacitors as an input system would solve both problems. Placing the sensors on the wrist band gives the user access to a bigger size input option than placing buttons on the side of the display and it allows for more input options, because more sensors can be placed on the wrist band than buttons or keypad around the display. Using the wrist band as an input device has not been an option in previous input system. In the next section we will discuss the implementation of touch sensors in other devices and how effective the results were.

3. Touch Sensors as Input Devices

Touch sensor capacitors are most popular for being used as an user input device for the iPod. They have also become a key element in rapid prototyping. Thumbtacks and foil can act as buttons or mimic mouse clicks. A circuit can then be created to measure the very small capacitance existing capacitively coupled path between the attached thumbtack and ground [6] . The capacitance is very low but is much higher when a person is very near to or touching the thumbtack or foil. The touch sensor operates by detecting significant changes in measured capacitance. No direct electrical connection is required, and the sensor is sensitive enough to operate reliably when the thumbtack is placed under a layer of masking tape. This allows the designer to optionally cover buttons and draw meaningful labels over them[6]. This will be useful with our prototype because once a sensor is touched; the emulator will be able to detect the input and process the information which tells which key was pressed. We are also able to label each sensor which will be useful for text entry.

Researchers at Keio University and Sony Computer Science Labs developed a PreSense Keypad. This keypad is also enhanced by touch sensors based on capacitive sensing [4] . Each keytop is an independent touch sensor, thus finger motions on the keypad are recognized by integrating each keytop's information. The PreSense is able to tell what key is about to be pressed before it is even pressed. This allows the user to preview the interface before the button is pressed.

4. Prototype

We have created a basic prototype to demonstrate how a wrist band with touch sensors would operate. A wristband was constructed out of a fabric band and six sensors were placed on the band. The sensors were made out of conductive copper fabric. Three sensors were placed above the display and three were placed below. Conductive thread was used to connect the sensor board to sensors. The wristband is double layered so that the conductive thread is not too sensitive or able to be touched outside the sensors. Each sensor on the board corresponds to a different binary number and when multiple keys are pressed, those numbers are added together. We then connected an USB Bit Whacker that process the data from the board and sends it through USB to the emulator on a PC. The emulator can then determine what function to display based off the data that is received. The prototype is shown in Fig. 1.

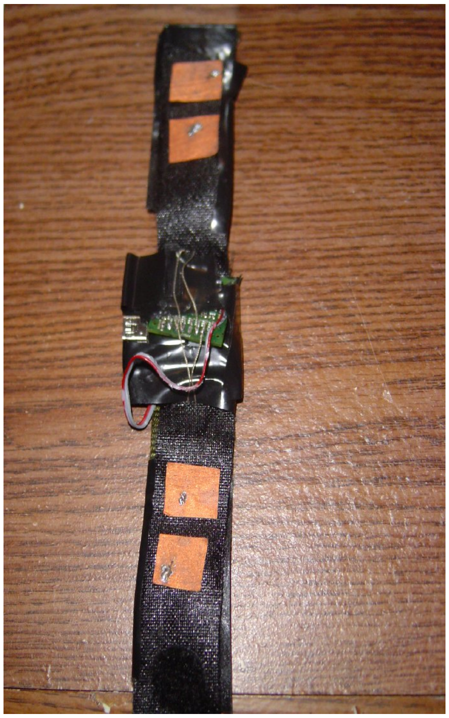

Fig. 1 Early prototype of wristband

We used the QT1080 touch sensor capacitor developed by the Quantum Research Group. The chip is designed for eight independent touch sensing fields allowing us to have eight different ways for input but we were only able to currently make use of six. The sensor is made to work in low power devices. A key feature to this chip is the Adjacent Key Suppression which suppresses touch from weaker responding keys and only registers the dominant key to be detected. [3] This is useful because on the wrist band, the keys will be place close together, if the user has large fingers it could make it difficult for the user to correctly use the input. We designed a circuit board to house the capacitor as well as the necessary capacitors and resistors. The board design is displayed in Fig.2 The board is currently powered by the Bit Whacker.

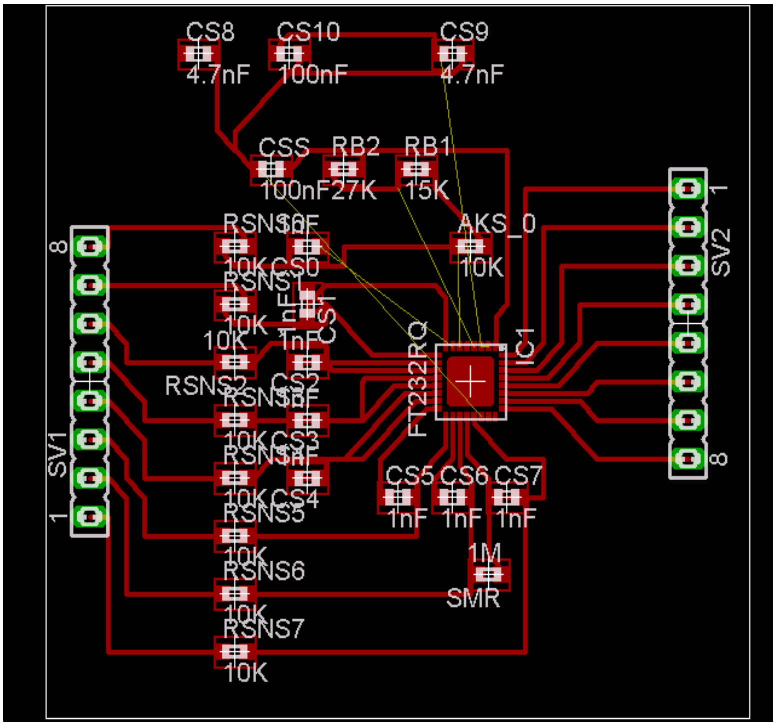

Fig. 2 Design layout of touch sensor board

5. Uses of sensors

To demonstrate potential uses of the wrist watch framework we developed a basic text editor to show text input by creating a emulator using the Java programming language. A diagram of the sensor layout is shown in Fig. 3.

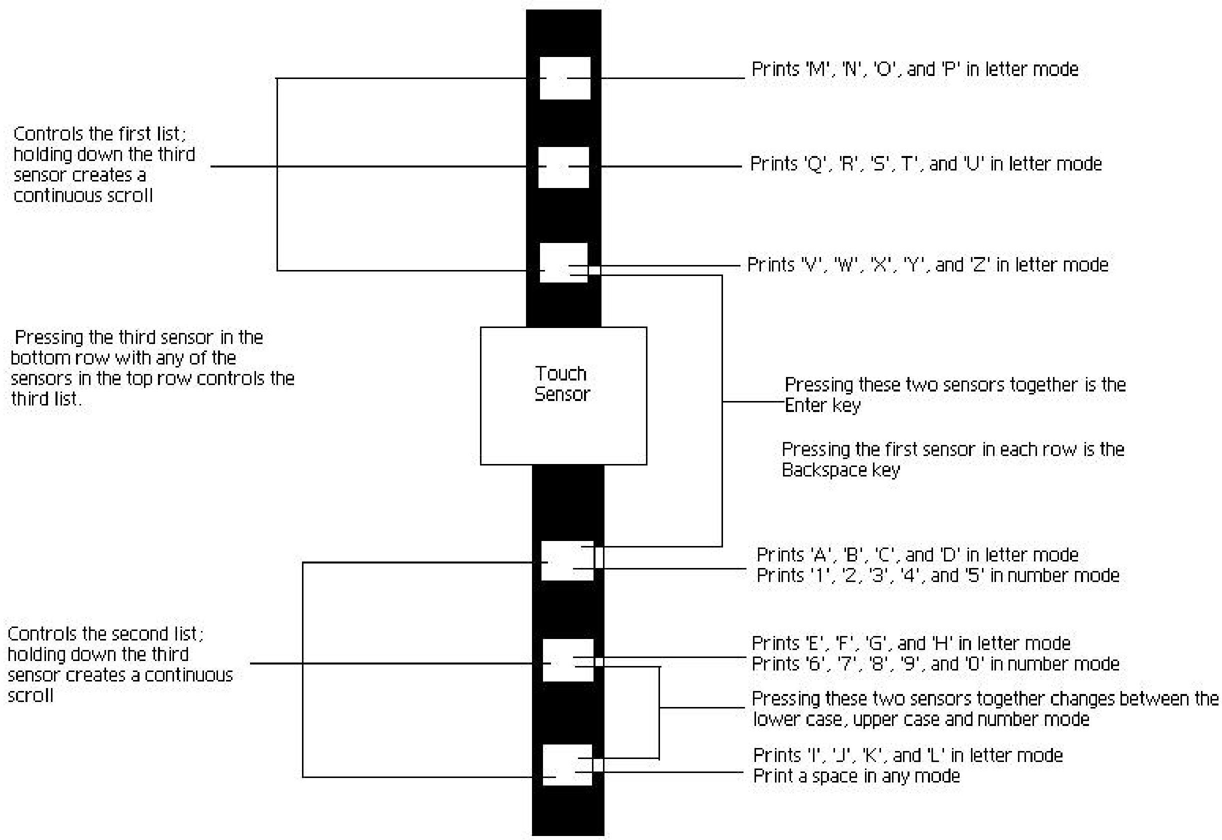

Fig. 3 Layout of sensors and their functions

Each sensor can print up to five alphabet characters depending on how many times the sensor is pressed as well as a “SPACE”, “BACKSPACE”, and an “ENTER” entry. For example, pressing the first sensor in the bottom row two times prints 'b', while pressing that same sensor five times prints 'a'. For times where other keys are needed like the “ENTER” or the change of mode key, we used two keys that were close together. This will allow for ease of use while also not blocking the area where a potential display would be placed. It will also make it easier for the user to remember the key layout.

This input system is similar to the text entry used in cell phones but touch sensors allow for faster input and the ability to use multiple sensors to allow for more input options.

We also are able to demonstrate how scrolling lists can be effective using the sensors. Three lists of different sizes were created. The top half of the sensors control the first list while the second half of the sensors control the second list. Pressing the last sensor on the top half or the bottom half of wristband creates a continuous scroll through the corresponding list. Pressing the top sensor and any of the bottom sensors control the third list. This method can be useful when scrolling through phone numbers, emails, or menu navigation. The interface for the prototype is shown in Fig.3

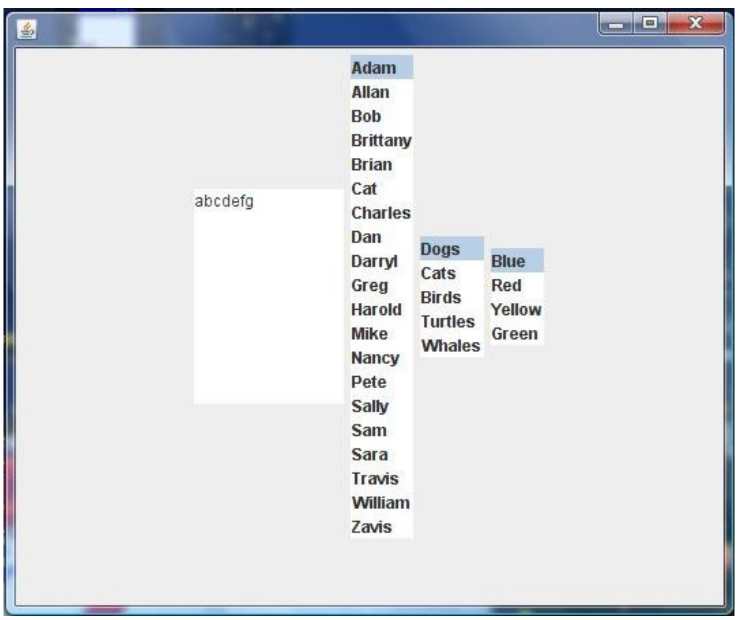

Fig. 3 Screenshot of a simple interface used to interact with wristband

6. Difficulties

The touch sensor is sometimes extra sensitive and can detect touch through solid objects.(i.e. table) This problem is probably caused by the construction of the sensor board. The makers of the board give recommendations of the resistor and capacitance values, but they tell you to use different values until you come up with the right combination so it may be possible to make the senor board less sensitive if we use a lower value of the resistors and capacitors. Initially we wanted to place eight sensors on the wrist band but so far we were only able to fit six. This problem could be fixed by having slightly smaller sensors. Also, even though using conductive thread as thus far been the most effective way to connect the sensors to the board, the more sensors that are on the board, the more interference between the sensors that is created. The interference happens despite the fact that each conductive thread is not touching the other.

7. Future Work

We would like to evaluate the ease of use of using the wrist band by conducting some user studies. We would conduct the studies by having users enter text and scroll between the different lists. Then interviews would be conducted to gain feedback on the user's experience with using the wrist band and how well they interacted with the layout. We also wish to create a display to be placed on the band so that we can test the difficulty level of using the touch sensors on the band in real world situations (i.e. walking, standing, multi-tasking). Currently, the wristband has to be connected to a computer to function but we would like to conduct studies with situations where the user would be moving around and using the wristband.

8. References

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